



JP5.7



Possible solar influences observed in GOES and MODIS total precipitable water product data

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Introduction: The bias correction of Geostationary Operational Environmental Satellite (GOES)-12 and -10 total precipitable water (TPW) product data reveals a correlation with solar illumination in the field of view (FOV). A daytime and nighttime solar difference was also noted in MODIS TPW data products. MODIS products appear to show a solar effect, but to a much lesser extent than GOES. Since the MODIS products studied used no first guess, we hypothesize the major detriment to GOES-derived TPW to be its first guess. We studied the GFS and NAM model forecast TPW compared to GPS TPW. GFS is currently used for the operational first-guess profile for GOES retrievals. Since NAM model data appeared better at zero hour (analysis time), we examined NAM forecasts at 3 and 6 hours. We show here that NAM integrated moisture-profile forecasts offer exceptional temporal stability. GOES-R advanced baseline imager soundings will require a first guess. Based on these results, we recommend testing the current GOES TPW product generation with a NAM first guess or improving the GFS first guess profile. GOES-R will benefit either way since a first guess will be required for GOES-R retrievals.

The following simple correction algorithm was devised to match the conventional GOES product TPW to GPS TPW.

$$G_c = aG^b$$

The coefficients (a and b) in the above equation were derived by minimizing the functional below that differences all GPS and GOES data.

$$J = \sum_{i=1}^N (G_{ci} - GPS_i)^2$$

Daylight effect on the correction algorithm coefficients.

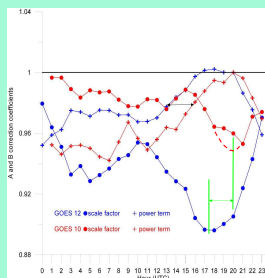


Fig. 1. Plot showing the a and b (scaling and power term) correction coefficients for both GOES 10 and GOES 12 as a function of hour (UTC). During dark hours (0-12 UTC) little correspondence is noted between the coefficients, however, during sunlit hours (12-23 UTC) similar response is seen. The approximate phase difference between the two curves during daylight is indicated by arrowed lines (black – power term, green – scaling term with vertical lines designating the separation in the minima). The dashed red line approximates a possible minimum in the scaling term for GOES 10. Fewer data for GOES 10 might have resulted in the absence of a clear minimum; however the scale factors retain a phase difference.

MODIS

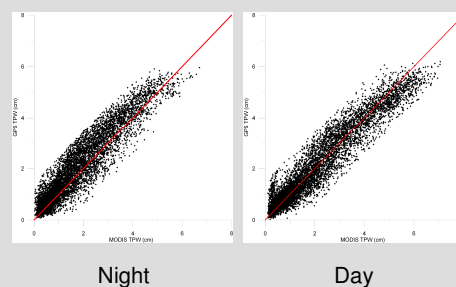


Fig. 2 Day and night scatter plots of MODIS TPW data vs. GPS TPW. A slight daytime moistening is indicated along with a better match during daylight hours. (no correction applied)

GFS and NAM zero-hour comparisons to GPS

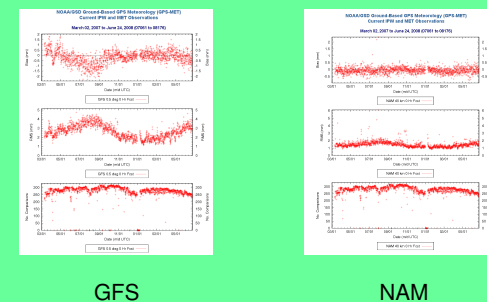


Fig. 4. Time series plots comparing model initial times with GFS and NAM to GPS. The top plot is difference (bias), center is sigma (RMS) error, and bottom is the data at each comparison time.

GOES

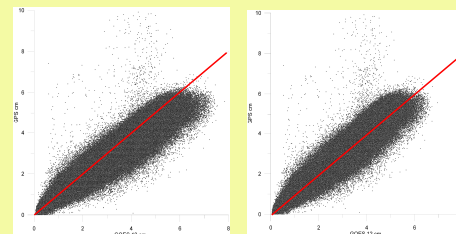
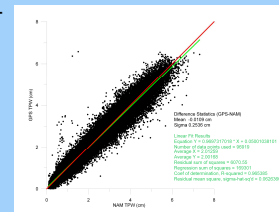
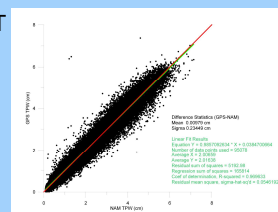


Fig. 3. Scatter plots of GOES-12 TPW showing the initial comparison (left) and after applying the correction algorithm (right).

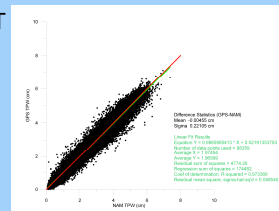
00UT



06UT



12UT



18UT

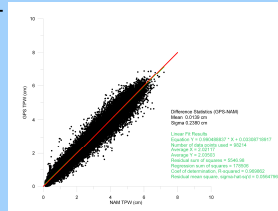


Fig. 5. Scatter plots of NAM 6-hour forecasts show excellent agreement with GPS validation. The scatter in the plots is typical of RAOB data, thus we deem the NAM forecasts as excellent first-guess data for retrieval work. Labels are initialization time, data span one full year.